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A Balloon Borne X-ray Survey of the
Central Region of the Galaxy

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ABSTRACT

A balloon borne x-ray survey of the galactic plane in the region of the galactic center was made from Australia during December 1966. The photon events recorded by a detector composed of a krypton gas proportional counter and a cesium iodide scintillation crystal are used to determine the spectrum of hard x-rays from the vicinity of Sgr XR-1.

We report here on evidence for hard x-rays from the vicinity of Sgr XR-1, near the galactic center. This result is based upon data collected during a balloon flight launched from Mildura, Australia on 18 December 1966. The residual atmosphere during the time of these measurements was 3.0-3.3 g/cm².

Figure I is a schematic representation of the gondola. Telescope A was vertical throughout the flight. Telescope B was programmed in zenith angle $\theta(t)$ and rotated in azimuth ϕ by the gondola at the rate of one revolution per 10 minutes; the earth's magnetic field was used as an azimuthal reference and an inertia ring served as the reservoir of angular momentum.

The main elements of telescope A are shown in Figure II-a. A structured response pattern was achieved for telescope A through the use of a copper occultation disk and annulus placed well above the detector. The effective detection cross section $A(\theta)$ is exhibited in Figure II-a as a function of the zenith angle θ of the incident radiation. This was obtained by measuring the counting rate due to a S_n^{119m} source placed at positions corresponding to several values of θ for a fixed radial distance of 12 ft.

Figure II-b shows the detector used for both telescope A and telescope B. The central element is a cesium iodide (thallium activated) scintillation crystal that is used to measure x-rays in the band $\sim 20 - 100$ KeV, partitioned by 64 channels. The geometry factor for the unocculted crystal (i.e. telescope B) is $2.95 \text{ cm}^2 \cdot \text{sr}$.

The plastic scintillator (CH) serves as an anticoincidence detector of charged particles and also as the innermost component of a three-element graded x-ray shield; the light from the CsI crystal is distinguished from that of the plastic scintillator by its longer decay time. The entrance port is a krypton gas proportional counter that serves as an anticoincidence detector and is also used to measure x-rays in the band $\sim 10 - 30$ KeV, partitioned by 64 channels. The transmission of the gas counter exceeds the 50% level at ~ 25 KeV.

The zenith angle θ of telescope B was programmed such that the telescope axis passed tangentially through the galactic plane upon each rotation of the gondola. Figure III shows six such passes from galactic north (during 0:39 - 1:39 U.T.) and then six subsequent passes from galactic south (during 3:01 - 4:01 U.T.) used for the present analysis. The programmed zenith angle θ for telescope B fixes the maximum magnitude of galactic latitude (b) attained by the telescope axis during each rotation (i.e. $|b|_{\max} = 2\theta$).

Figure IV shows the raw counts obtained from a superposition of epochs, phased in azimuth with respect to Sgr XR-1 (coordinates as given by Friedman et al., 1967). The passes from galactic north as well as those from galactic south exhibit a minimum counting rate for azimuthal angles near 180° . The dominant feature of the superposition of passes from galactic north is the signal detected from Sco X-1 by the krypton gas counter. In contrast, the dominant feature of the

superposition of passes from galactic south is the signal from the vicinity of Sgr XR-1 detected by the cesium iodide crystal. This is a strong qualitative indication of the relative hardness of the two spectra.

The six passes through the galactic plane from galactic south are used to determine the spectrum of x-rays from the vicinity of Sgr XR-1. Data from azimuthal angles 288° - 360° (0°)- 72° relative to Sgr XR-1 are used for the gross signal while the data from 108° - 180° - 252° are used for the background. When the suitable corrections are applied (i.e. detection efficiency for a source at the position of Sgr XR-1, atmospheric attenuation), the spectrum obtained for the corresponding beam incident upon the top of the atmosphere is shown in Figure V. The lowest energy interval indicates the data obtained from the krypton gas counter; the other six intervals were obtained from the data recorded by the CsI crystal. These data indicate a spectrum for the x-rays from the vicinity of Sgr XR-1 that is similar to the spectrum for the x-rays from the Crab nebula, Tau XR-1 (Peterson, 1966). This observation extends the spectral indication for the galactic center region obtained from rockets (Giacconi et al., 1966).

As shown in Figure III, there were other possible sources that passed near the meridian at the sidereal time for SgrXR-1. Therefore, it is necessary to distinguish the appropriate declination. In this connection, we note that during the meridian passage of Sgr XR-1 it was at maximum visibility for telescope A and that at this particular time the sun was occulted by the annulus of this unit. The observed counting rate (dN/dt) of the CsI scintillator for telescope A, in the band 22 - 60 KeV, is here folded with the effective detection cross section $A(\theta)$ for data collected during $\Delta t = 180$ minutes, starting at $t = 0:50$ U.T., viz:

$$(\text{Folded rate}) \equiv \frac{\int_t^{(t+\Delta t)} \frac{dN}{dt} A(t) dt}{\int_t^{(t+\Delta t)} A(t) dt} \quad (1)$$

The area $A(t)$ at time (t) is fixed by the zenith angle θ between the hypothetical celestial object under consideration and the actual axis of telescope A at that time. We consider candidate declinations over the interval $\delta = -34^\circ \pm 15^\circ$ at a fixed right ascension of 270° and examine the increment between the folded rate (1) and the average rate (2) for the same data sample, viz:

$$(\text{Average rate}) \equiv \frac{\int_t^{(t+\Delta t)} \frac{dN}{dt} dt}{\Delta t} \quad (2)$$

The corresponding curve shown in Figure VI exhibits a maximum at a declination close to that reported by Friedman et al (1967) for Sgr XR-1 and a negative correlation for the sun.

It is a pleasure to thank Walter Nagel for the orientation system, Eric Curwood and the Australian Department of Supply for the balloon flight, and Frank B. McDonald for his encouragement.

FIGURE CAPTIONS

Figure I

A schematic representation of the gondola.

Figure II

- a) Telescope A utilizes the occultation scheme outlined; the detector appears at the bottom.
- b) The essential features of the detector used for both telescopes (A and B).

Figure III

The scan of the galactic plane executed by telescope B.

Figure IV

The counting rate recorded by telescope B.

Figure V

The spectrum of X-rays from the vicinity of Sgr XR-1

Figure VI

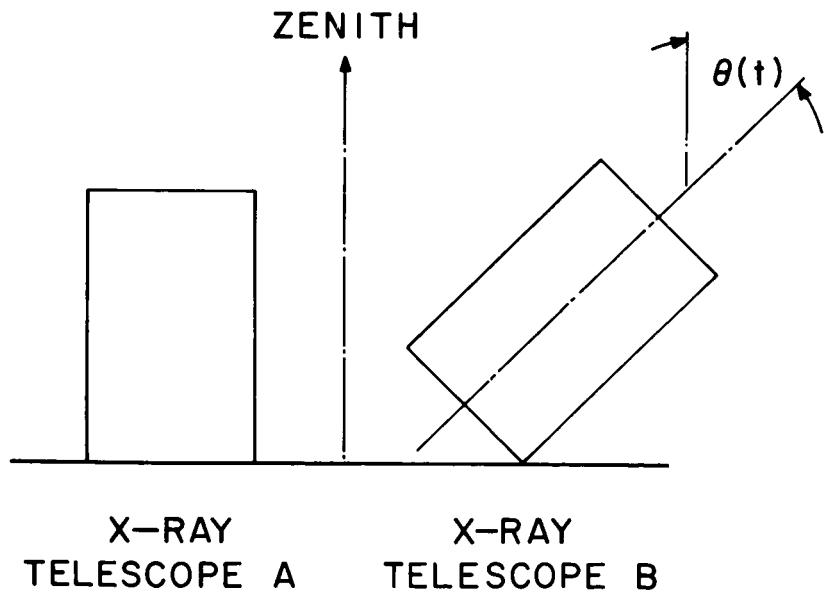
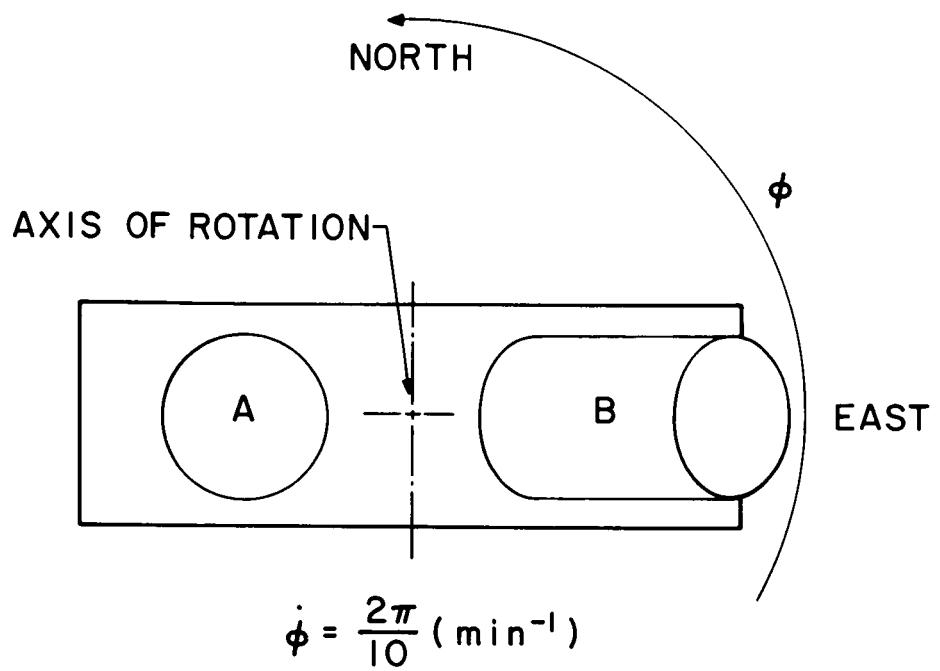
A determination of the dominant source declination based upon the counting rate from telescope A, over the band 22-60 keV for the CsI crystal.

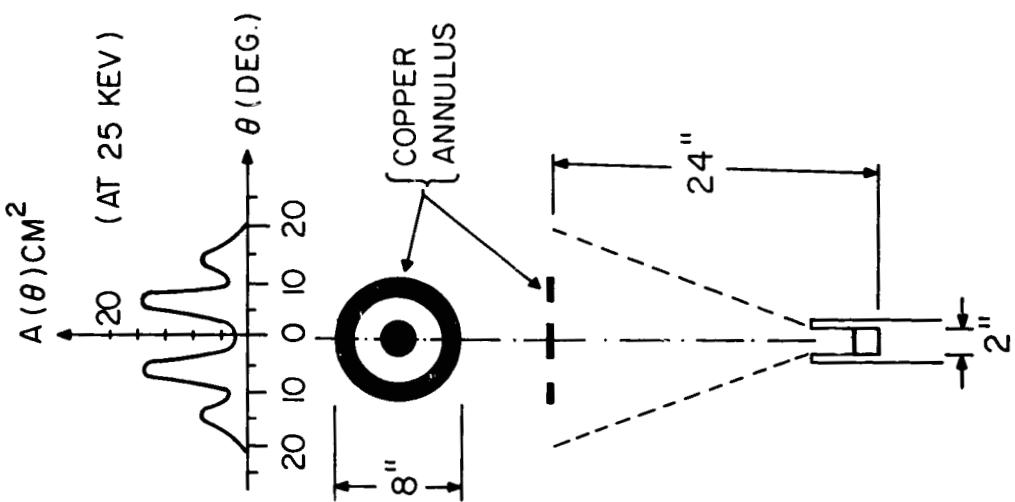
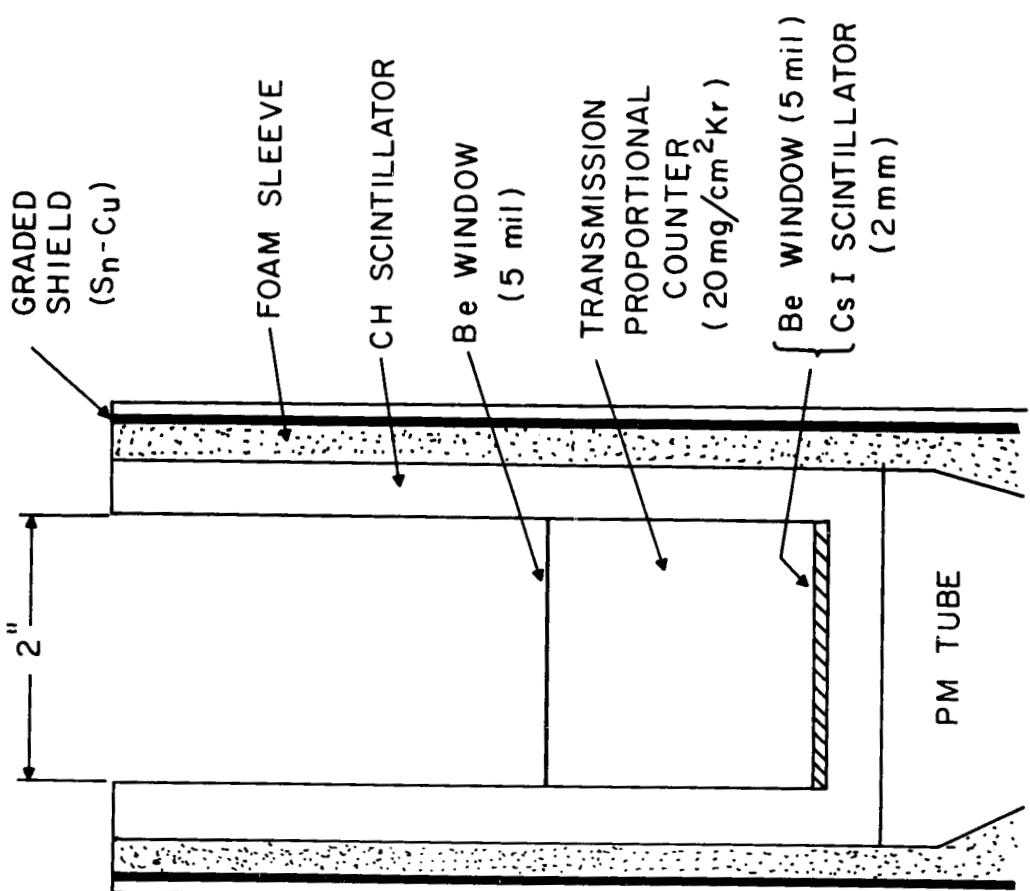
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(b)

(a)

